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(54) **Improvements related to ball-and-socket joints**

(57) A ball-and-socket joint comprises a male coupling member 1 having a ball end with a forward facing convex part-spherical surface 2 covered by a collar 9 having a complementary concave part-spherical surface, the ball end having a rearward facing convex part-spherical surface 3 engaging with a complementary concave part-spherical surface of a hub 4 held swivellably in contact therewith by retaining means 6 fastened to the male coupling member 1. The collar 9 is secured at 10 to the hub 4. The coupling is completed by clamping the hub 4 to a female coupling member 11 including a socket 12 to receive sealingly the external surface of the colllar 9.

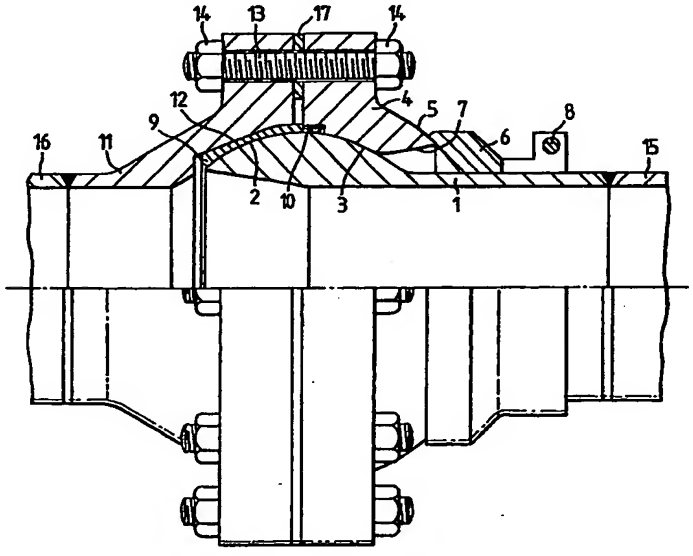

Fig.1

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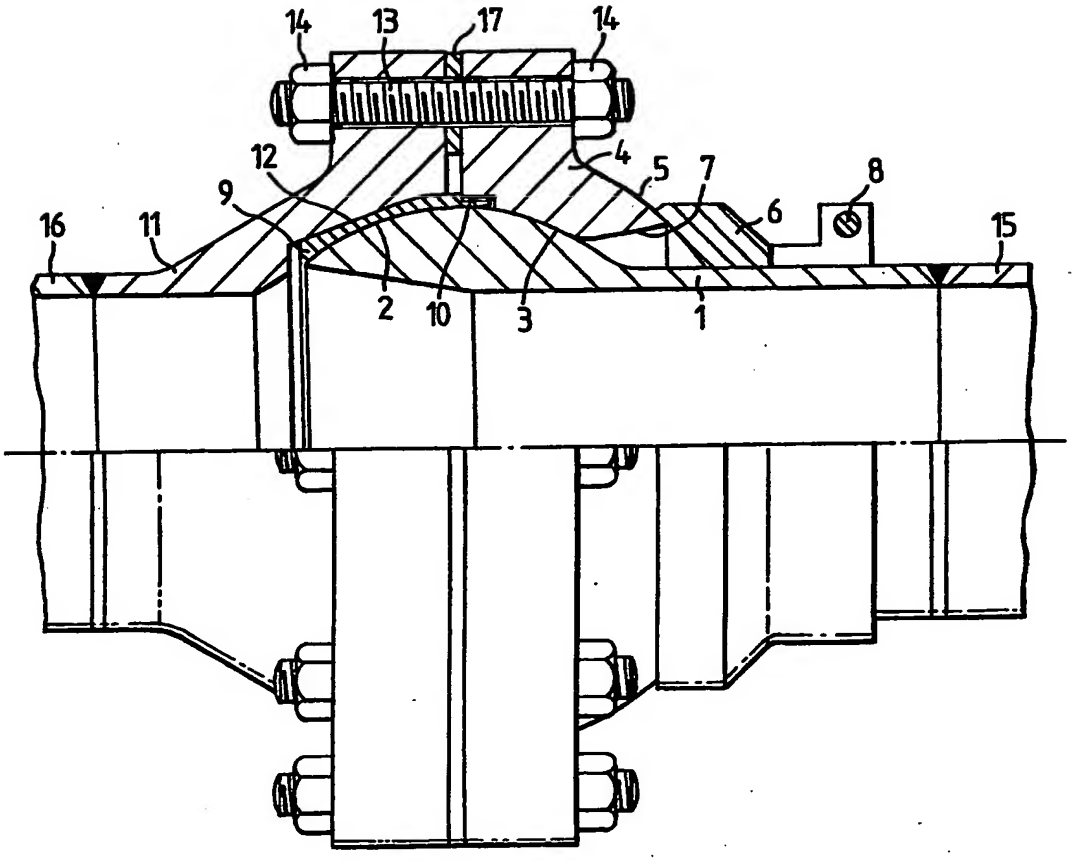

Fig.1

SPECIFICATION

Improvements related to ball and socket joints

This invention relates to ball and socket joints for underwater pipelines as described in U.K. patent no. 1,558,763, U.S. patent no. 4,139,221, and Canadian patents' nos. 1,080,274 and 1,092,624. The first three patents describe a joint having a collar pre-assembled on the ball or enlarged portion (i.e. assembled before immersion and positioning on the seabed where pipe connection is to be made). The collar comprises two ring-shaped parts with forward and rearward facing spherical surfaces on the ball respectively. The fourth patent, Canadian patent no. 1,092,624, describes a joint having a hub held in contact with the rearward facing spherical surface of the ball by means which allow the hub to swivel with respect to the ball about diametrical axes orthogonal to the bore axis before connection is made. These two inventions can be combined with advantage to give an improved ball and socket joint.

According to this invention, a ball and socket joint includes:

a hub with a spherical internal surface capable of engagement with a rearward facing spherical surface of the ball;

means to hold the hub in contact with the rearward facing spherical surface of the ball and effective to allow the hub to swivel with respect to the ball about diametrical axes orthogonal to the bore axis before connection is made; and

a ring-shaped part with a spherical internal surface capable of mating engagement with a forward facing spherical surface of the ball and incorporating means for attachment to, and disengagement from, the hub.

Advantageously, the ring-shaped part has a cross-section similar to part 4 of Fig. 1 of U.K. patent no. 1,558,763, but does not necessarily contain resilient seals. It can be manufactured from a 'softer' metal than the ball and socket, i.e. the yield point stress of the ring-shaped part material can be less than the yield point stress of the ball and socket materials.

Sealing is then effected by local yielding of the ring-shaped part material when compressed, and this characteristic combined with its shape enables the ring-shaped part to behave similarly to the Laurent seal used in National wellhead connectors. For a typical underwater pipeline connector, all materials will be steel, but the ring-shaped part can be a 'softer' grade, and may be stainless.

The means for attaching the ring-shaped part to the hub can be a plurality of screws in a similar manner to parts 6 of Fig. 1 of U.K. patent no. 1,558,763, or can be a bayonet fitting similar to that of a typical electric light bulb, or can be a single or multiple start thread.

In order that the present invention may be more readily understood, the following description of a specific example is given for illustration, reference being made to the accompanying drawing.

Fig. 1 is a part cross-sectional view of the assembled ball and socket joint. The ball coupling member 1 is welded at one end to pipe 15 and has a forward facing spherical surface 2 and a rearward facing spherical surface 3. A hub 4 is in mating contact with surface 3 and has an external spherical surface 5 which engages retaining collar 6. Hub 4 is thus held in contact with surface 3, but is free to swivel within the limits of conical bore 7. Screw 8 clamps retaining collar 6 to coupling member 1. Ring-shaped part 9 is attached to hub 4 by thread 10. Items 1 to 10 constitute the ball coupling member of the joint, and are assembled and attached to pipe 15 prior to immersion and lowering to an underwater location where connection is required.

Socket coupling member 11 is welded at one end to pipe 16 and has a frusto-conical internal surface 12. When the ball coupling member 1 enters socket coupling member 11 to form a connection, the ring-shaped part 9 approaches surface 12.

The parts 9 and 11 are shaped for mating engagement at surface 12 and when in contact, the studs 13 are assembled between the hub 4 and socket 11 with tensioning nuts 14. Tension developed in the studs 13 results in a pre-load compressive stress in ring 9 which causes 'soft' metal ring 9 to seal against both surface 2 and surface 12. Ring 9 and Hub 4 may be connected so that there is little resistance to the tension in studs 13 forcing ring 9 and hub 4 towards each other. This can be done by arranging thread 10 to have less than one turn.

If the joint does not withstand an internal pressure test, then it can be disconnected and ring 9 can be detached for inspection. A replacement ring-shaped part 9 can then be attached to hub 4 and the joint can be re-connected for a further pressure test.

Rubber annulus 17 is glued to socket coupling member 11 and acts as a 'buffer' when ball coupling member 1, with hub 4 attached, enters socket 11. Hub 4 can be about 20 degrees out of alignment with the face of socket 11, and as ball 1 moves into socket 11, the leading edge of hub 4 strikes rubber annulus 17. As ball 1 enters socket 11 further, hub 4 swivels around ball 1, moving into parallel alignment with the face of socket 11 when ball 1 has fully entered socket 11. Annulus 17 could be manufactured from sponge rubber so that when tension is applied to studs 13, the annulus 17 is more readily deformable and absorbs less of the tension in studs 13. Annulus 17 also acts to prevent circulation of water between the flange faces of hub 4 and socket 11, thus reducing corrosion.

Alternatively, but without the benefit of the sealing action of annulus 17, a plurality of small rubber strip or disc 'buffers' could be used to align the face of hub 4 with socket 11.

CLAIMS

1. A ball-and-socket coupling comprising a male coupling member having a bore along its longitudinal axis, and a ball end with a forward-facing convex spherical surface and a rearward-facing conv x

spherical surface; a female coupling member having a socket entered by said ball end of the male coupling member upon assembly of the coupling; a hub member having a concave spherical surface to engage said rear-ward-facing convex spherical surface of the ball end of the first coupling member; means for holding the hub on the ball end with said concave spherical surface of the hub in constant engagement with said rearward-facing convex spherical surface of the ball end before connection and allowing swivelling of the hub about the male coupling member longitudinal axis and about any diametral axis of the ball end which is orthogonal to the longitudinal axis of said male coupling member; a collar having a concave spherical surface for engagement with said forward-facing convex spherical surface of the ball end of said male member; and clamping means operable to clamp said hub to said female coupling member, said collar being arranged to engage sealingly in said socket when the hub is drawn into engagement with said female coupling member and clamped thereto, wherein the collar is secured to said hub on the exterior of the ball end by means other than the clamping means holding the hub and the female coupling member together, whereby the collar is retained on the forward facing convex spherical surface of the ball end of the male coupling member even before assembly of the coupling.

2. A coupling according to claim 1, wherein said collar is made of a metal which has a lower yield point than the material of said male and female coupling members.

3. A coupling according to claim 2, wherein the said collar is made of stainless steel, and said male coupling member and female coupling member are made of steel.

4. A coupling according to any one of claims 1 to 3, wherein said collar is secured to said hub by means of screws extending parallel to the axis of symmetry of said hub.

5. A coupling according to any one of claims 1 to 3, wherein said collar has an axially extending spigot engaging with a complementary recess of the hub, the spigot and recess including co-operating thread formations to allow the collar to be screwed into position on said hub.

6. A coupling according to claim 5, wherein said complementary thread formations each comprise a multi-start thread.

7. A coupling according to claim 5 or claim 6, wherein the or each thread start of the co-operating thread formations of the spigot and recess occupies less than one turn.

8. A coupling according to any one of claims 1 to 3, wherein the collar is secured to the hub by means of a bayonet-type coupling.

9. A coupling according to any one of the preceding claims, wherein the socket has a frusto-conical internal surface and the collar has a complementary frusto-conical external surface.

10. A coupling according to any one of the preceding claims, wherein the female coupling member and the hub have respective flat abutment surfaces extending perpendicular to the axis of rotational symmetry of the respective one of the female coupling member and hub, and including resilient facing material covering said flat abutment surfaces.

11. A coupling according to claim 10, wherein said facing material is of sponge rubber.

12. A coupling according to claim 10 or 11, wherein said facing material extends continuously over an annular area of said flat abutment surface to form a seal against ingress of ambient fluid between said flat abutment surfaces and into the interior of a closed housing defined by the hub and socket when the coupling is assembled.

13. A ball-and-socket coupling substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawing.

14. A method of assembling a ball-and-socket coupling according to claim 1, comprising securing said collar to the hub before offering up the hub to the socket of said female coupling member, whereby the collar serves as a protection for the forward facing convex spherical surface of the ball end; offering up said hub to said socket by inserting the ball end and encircling collar into said socket of the female coupling member; clamping said hub to said female coupling member; and then pressure testing said coupling and, if the coupling is found to fail the pressure test, dismantling the coupling and replacing the first-mentioned collar by a fresh collar and then re-assembling and testing the coupling.

15. A process according to claim 14, wherein the coupling is to be connected underwater and the collar is attached to the hub before immersion of the male coupling member.

16. A method according to claim 14 or 15 wherein, when the hub is offered up to the female coupling member, the hub is rotationally misaligned with respect to the female coupling member, about a diametral axis which is orthogonal to the axis of the bore in said male coupling member, and alignment of the hub and female coupling member is allowed to take place automatically as the hub and female coupling member are brought into contact with one another.

17. A method of assembling a ball-and-socket coupling substantially as hereinbefore described with reference to the accompanying drawing.

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